

Sample Acquisition and Analytical Chemistry Challenges to Verifying Compliance to Aviator's Breathing Oxygen (ABO) Purity Specification

John Graf

Life Support Systems Branch, Mail Code EC3, NASA Johnson Space Center – Houston TX

Abstract submitted to the 2015

Oxygen Standardization Coordinating Group Meeting

Abstract:

NASA has been developing and testing two different types of oxygen separation systems. One type of oxygen separation system uses pressure swing technology, the other type uses a solid electrolyte electrochemical oxygen separation cell. Both development systems have been subjected to long term testing, and performance testing under a variety of environmental and operational conditions.

Testing these two systems revealed that measuring the product purity of oxygen, and determining if an oxygen separation device meets Aviator's Breathing Oxygen (ABO) specifications is a subtle and sometimes difficult analytical chemistry job. Verifying product purity of cryogenically produced oxygen presents a different set of analytical chemistry challenges.

This presentation will describe some of the sample acquisition and analytical chemistry challenges presented by verifying oxygen produced by an oxygen separator – and verifying oxygen produced by cryogenic separation processes.

The primary contaminant that causes gas samples to fail to meet ABO requirements is water. The maximum amount of water vapor allowed is 7 ppmv. The principal challenge of verifying oxygen produced by an oxygen separator is that it is produced relatively slowly, and at comparatively low temperatures. A short term failure that occurs for just a few minutes in the course of a 1 week run could cause an entire tank to be rejected. Continuous monitoring of oxygen purity and water vapor could identify problems as soon as they occur. Long term oxygen separator tests were instrumented with an oxygen analyzer and with a hygrometer: a GE Moisture Monitor Series 35. This hygrometer uses an aluminum oxide sensor. The user's manual does not report this, but long term exposure to pure oxygen causes the aluminum oxide sensor head to bias dry. Oxygen product that exceeded the 7 ppm specification was improperly accepted, because the sensor had biased. The bias is permanent – exposure to air does not cause the sensor to return to its original response – but the bias can be accounted for by recalibrating the sensor. After this issue was found, continuous measurements of water vapor in the oxygen product were made using an FTIR. The FTIR cell is relatively large, so response time is slow – but moisture measurements were repeatable and accurate.

Verifying ABO compliance for oxygen produced by commercial cryogenic processes has a different set of sample acquisition and analytical chemistry challenges. Customers want analytical chemists to conserve as much as possible. Hygrometers are not exposed to hours of continuous flow of oxygen, so they don't bias, but small amounts of contamination in valves can cause a "fail". K bottles are periodically cleaned and recertified – after cleaning residual moisture can cause a "fail". Operators let bottle pressure drop to room pressure, introduce outside air into the bottle, and the subsequent fill will "fail". Outside storage of K-bottles has allowed enough in-leakage, so contents will "fail".